DTE Energy
Hydrogen Technology Park
2005 DOE Program Review

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May, 2005
Project ID: TV-2

Overview

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Timeline:

Start Date:	Oct 2002
Orig End Date:	Oct 2005
New End Date:	Oct 2009
% complete:	~ 60%

Barriers:

C. Hydrogen Refueling Infrastructure

E. Codes and Standards

H. Hydrogen from Renewable Resources

I. Hydrogen and Electricity Co-production

Budget:

Total (revised): $4 M

- DOE share: $2 M
- Cost share: $2 M

FY04 funding: $2 M

FY05 funding: $0.6M

Partners/Collaborators:

- DaimlerChrysler
- BP
- Lawrence Technological University (LTU)
- Sandia National Laboratories

Objectives

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Project Objectives

Develop and test a hydrogen co-production facility having stationary fuel cell power and vehicle fueling capability that uses renewable & non-renewable resources (FY04)

Employ representative commercial units under real-world operating conditions (FY04)

Based on performance data, project experience, and market assessments evaluate the technical and economic viability of the power park system (FY05)

DOE Objectives

By 2008, validate an electrolyzer (powered by a wind turbine) with capital cost of $600/kWe and efficiency of 68% (incl. compression to 5,000 psi)*

By 2008, develop a dist gen PEM fuel cell system that achieves 32% electrical efficiency and 20,000 hours durability at $1500/kW

***when built in quantities of 1,000**

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Objectives

Project Objectives

Contribute to development of relevant safety standards & codes required for commercialization of hydrogen-based energy systems (FY04)

Identify system optimization and cost reduction opportunities including design footprint, co-production, and peak-shaving applications (FY05)

Increase public awareness and acceptance of hydrogen-based energy systems (FY04)

DOE Objectives

Determine the relevant codes, safety standards, and engineering data required for Power Parks

Obtain real-world operating data to better understand performance, maintenance, operation, and economic viability of Power Parks

Approach:
Project Overview

Design, install, and operate an integrated hydrogen co-production facility utilizing:

- Electrolytic hydrogen production
- 50kW stationary fuel cell power
- 5000 psig vehicle dispensing
- Renewable on-site solar energy
- Grid-connected biomass energy

Collect, analyze, and report system performance data & lessons learned for an integrated co-production facility operating under real-world conditions

Evaluate commercialization opportunities for an advanced Power Park facility

Approach:
Process Flow Diagram

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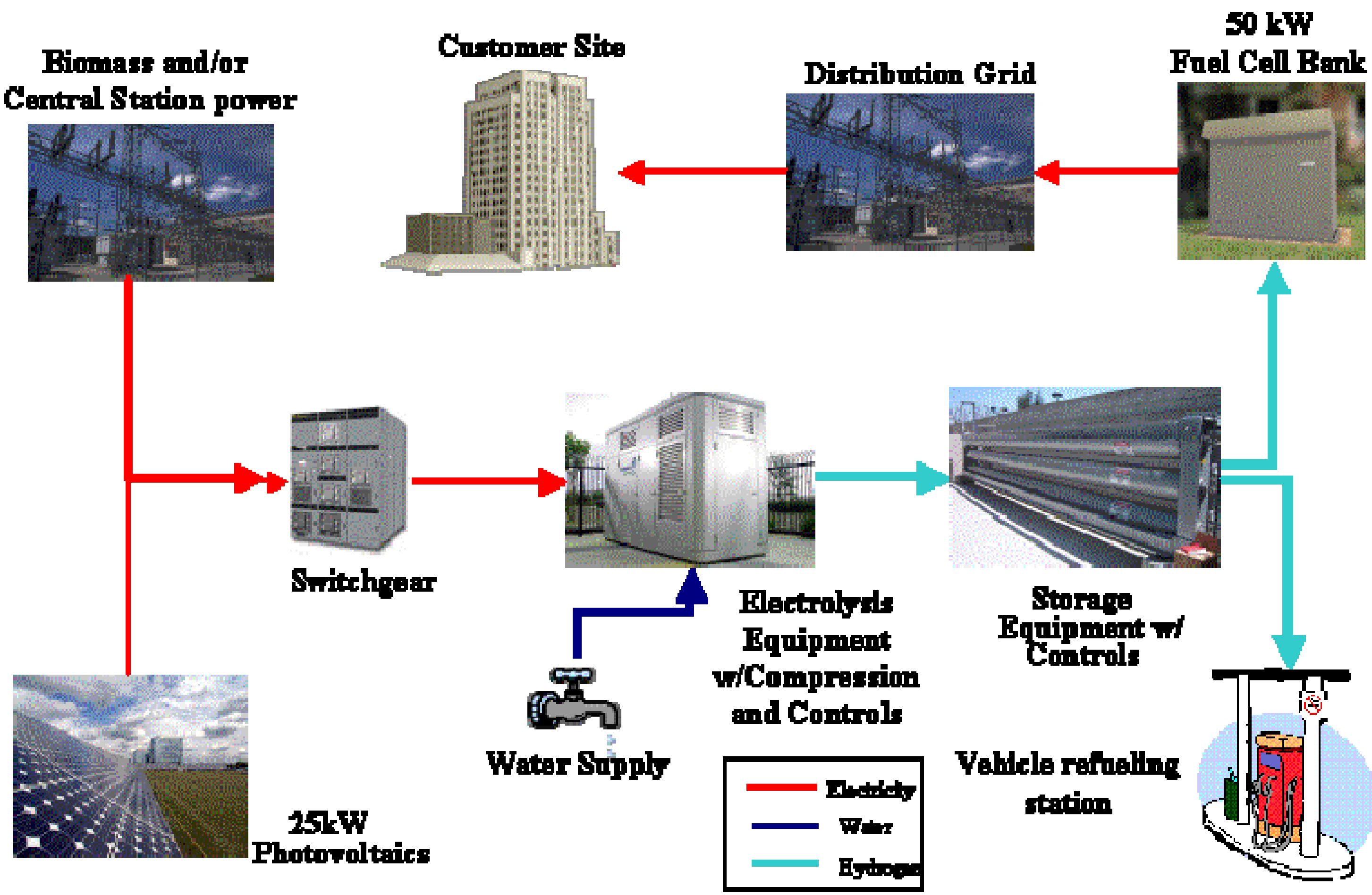
System Operations Center *(not shown)*:

- Provides remote monitoring & control
- Improved economics through reduced O&M costs



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Accomplishments:
System Installed & Operating

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System installed
October 2004:

- Integrated co-production facility developed and installed per project plan

- Capable of producing 60 kg/day of 99.995% pure hydrogen using on-site solar and grid power

- Capable of generating 400 kwh/day of emission-free electricity using installed fuel cell systems

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Accomplishments:
System Installed & Operating

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System installed
October 2004:

- Capable of dispensing 15 kg/day of compressed hydrogen @ 5000 psig

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Accomplishments:
Employed Representative Commercial Units Operating under Real-World Conditions

Fuel Cell Power System (50kW)

engineered solution

Electrolyzer (2.7kg/hr @ 5700psig)

Accomplishments:
Employed Representative Commercial Units Operating under Real-World Conditions

Dispenser
(CaFCP Type I & II fills)

Storage & GCP
(134 kg @ 5700 psig)

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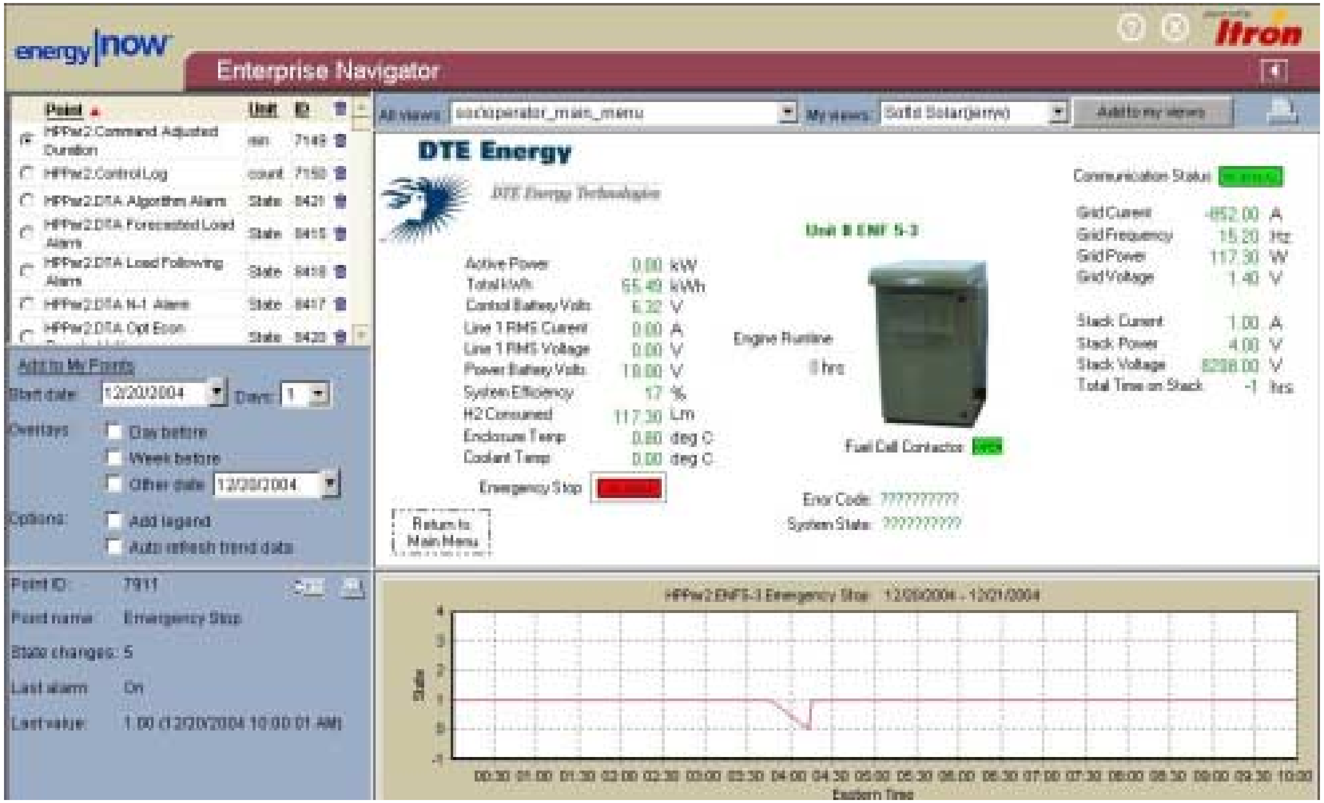
Accomplishments:
Implemented Remote Monitoring & Control System

- Remote start/stop capability for unmanned operation
- Monitors and records all relevant system parameters
- Provides alarms & warnings



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Accomplishments:
Executed on Safety Program

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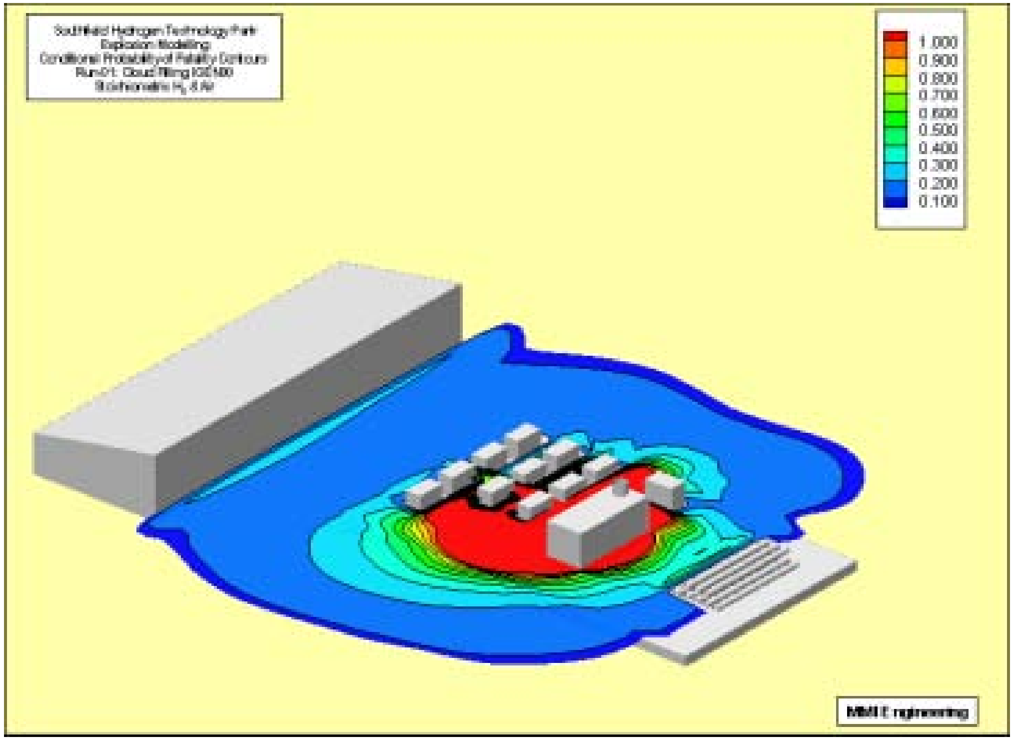
- Conducted HAZID and QRA (sponsored by BP)
- Reviewed vendor FMEAs and HAZOP:
  - Identified shortcomings with vendor design (HWSS and dispenser)
  - Worked with vendors to re-design control circuits to be control reliable
- Completed system interface analysis & code review
- Initiated O&SHA



QRA contour plot

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Accomplishments:
Executed on Safety Program

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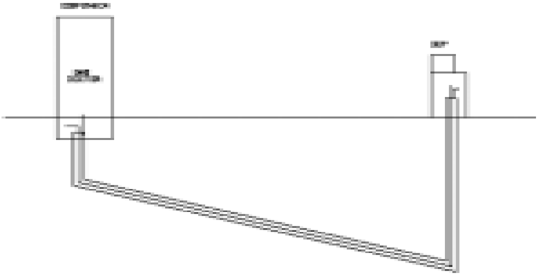
Designed and implemented continuous, concentric poly-propylene sleeve application for buried hydrogen supply line to dispenser:

- Seamless stainless steel line inside
- Pitched installation to vent at dispenser & GCP

With non-odorized gas, further guarantees the integrity of buried hydrogen supply line



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Accomplishments:
Facility Designed for Cold Weather Operation

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Cold weather operation required special design considerations and remediation of equipment freezing problems:

- Fuel cell drains routed below frost line
- Water supply extensively heat taped
- Insulation provided under electrolyzer
- T-stat controlled heaters installed on all equipment
- Provided new design for vent stack in lieu of rain cap

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Accomplishments:
Developed & Conducted Site Acceptance Tests

- **System pressure testing to ANSI B31.3** (complete)
- **HWSS and E-stop ckt** (complete)
- **Hydrogen Detectors** (complete)
- **Electrolyzer SAT** (in progress)
  - **Capacity test**
  - **PLC controls**
  - **Purity tests (results)**
  - **Compressor**
- **Gas Control Panel/storage** (complete)
- **Dispenser** (complete)
  - **CAFCP 6.1 protocol (Type I & II)**
- **Fuel cell system** (complete)
- **Security/Alarm & warning system** (in progress)

Dispenser Hose Breakaway Release Test:

The hose breakaway coupling is designed to release when 150 pounds force is applied.

Acceptance Criteria

Hose breakaway will release from the hose bracket when sufficient force is applied.

Test Procedure

Test Procedure	PASS/FAIL
INITIAL CONDITIONS: Dispenser is not pressurized and the breakaway is wrapped in protective foam to prevent unnecessary scratching of the cabinet.	
1. Hold the hose and walk away from the dispenser until the hose is tight (approx. 6 feet).	

Accomplishments:
Initiated Data Collection & Analysis Work

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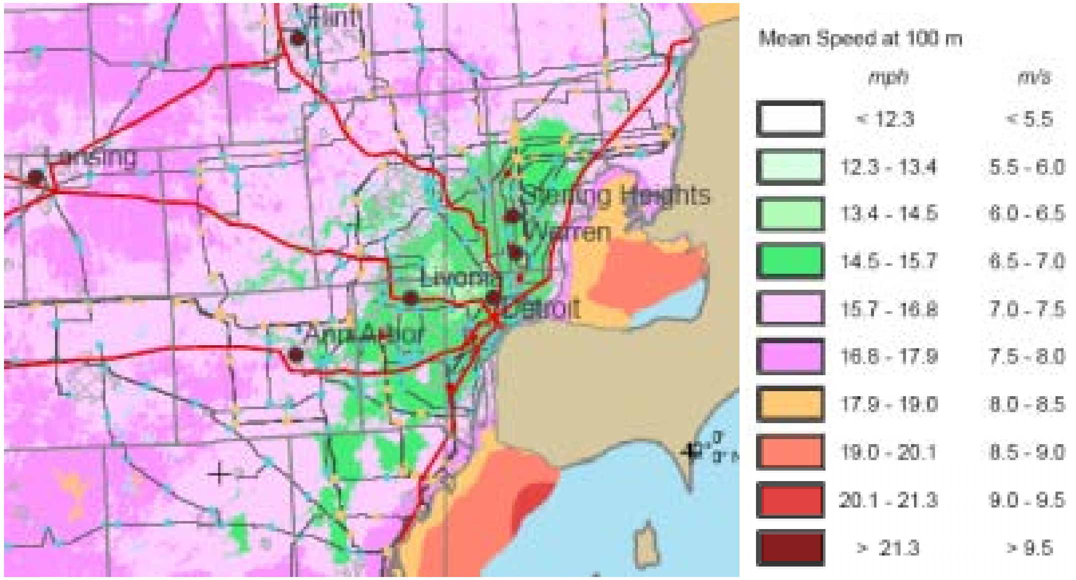
- **Preliminary system data collected & assessed**
- **LTU academic partner:**
  - Conducted wind study/economics
  - Web-based interface established for data downloads
  - Automating data collection process
- **Initiated system modeling work with Sandia National Laboratories**
- **Defined economic/market analysis master's project with University of Michigan student team (SNRE)**



Preliminary costs estimates for seasonal energy from a 1.6 MW wind turbine in Southfield, MI

Season	Typical Seasonal Capacity Factor	$ per kW-hr
Summer (July and August)	0.07 to 0.09	$0.11 to $0.14 per kWh or higher
Spring and Fall	0.11 to 0.17	$0.05 to $0.08 per kWh
Winter	0.17 to 0.19	~ $0.04 per kWh

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Accomplishments:
Integrating Site into Fleet Demo Program

- Conducted initial fueling of DaimlerChrysler and Ford vehicles
- Provided Q1&2 infrastructure data to NREL
- DCX customer in place for regular station use

Hydrogen Purity Log

Report Date		3/31/2005		
Energy Provider		DTE Energy Hydrogen Technology Park		
Unique Station Identifier		25613	Date [3]	
	Metric	Units	9/20/04	2/28/05
1	Hydrogen Purity [2]	%, dry	99.9950%	99.9950%
2	CO [1]	ppm	<1	<1
3	CO_2 [1]	ppm	<1	<1
5	H_2S [1]	ppm	<1	<0.008

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Accomplishments:
Increased Public Awareness of Hydrogen-based Energy Systems

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Held Ground-Breaking & Site Dedication Events

June '04

October 2004

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Accomplishments:
Increased Public Awareness of Hydrogen-based Energy Systems

Developed Project Video

Other Accomplishments

- **Codes & Standards:**
  - Participant in Michigan Department of Environmental Quality (MDEQ) Hydrogen Ad Hoc Committee
  - Participant in NextEnergy Hydrogen Infrastructure Working Group
  - Co-developed rapid mass loss detection system w/vendor
  - Designed and installed Positron (isolator) & additional grounding because of substation potential gradient concern
- **Other Collaboration:**
  - DG aggregation study (DOE)

FY04 Comments & Responses

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Strengths

- **Good SCADA approach; Good safety plan; Good leverage of resources; Good life of project – 2008**
- **Project is valid and worthwhile**

Weaknesses

- **Partners seem too limited for such a broad based project –** full complement of partners necessary to achieve project objectives now in place: slides 2, 12, 16, 17, 20.
- **Lack of quantitative goals –** addressed: see slide 3.

Specific recommendations and additions or deletions to the work scope

- **More structured collaboration and tech transfer plan could be considered –** addressed (above).
- **Would like to see as much of the data as possible be made public (subject to agreement by your hardware suppliers) –** data reports being submitted to NREL per fleet demo project agreements.
- **Develop quantitative project goals and contingency plans if their goals are not met on schedule –** addressed (above).

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Future Work (FY05-06)

- Complete SAT’s/procedures and fully commission site
- Maximize safe operation of site to support data collection, analysis, and optimization work
- Continue education & outreach activities
- Fully integrate site into Controlled Fleet Demonstration Project (FY05-FY08)
- Continue participation in codes & standards and hydrogen working groups
- Develop initial project reports (incl. recommendations)

(I believe)

(I believe)
(I believe)
(I believe)
(I believe)
(I believe)

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Supplemental Slides

(I believe)
(I believe)

Publications & Presentations

Presentations:

- R. Regan, "DTE Energy Hydrogen Technology Park," SAE Government/Industry Meeting, Washington, DC (May 2005)
- R. Regan, "DTE Energy Hydrogen Technology Park," Alternative Energy Symposium (St. Clair County Community College), Port Huron, MI (April 2005)
- R. Regan, "DTE Energy Hydrogen Technology Park," Rochester Institute of Technology, Rochester, NY (April 2005)
- R. Regan, "DTE Energy Hydrogen Technology Park," University of Michigan Concentration in Environmental Sustainability Program, Ann Arbor, MI (April 2005)
- R. Regan, "DTE Energy Hydrogen Technology Park," 2004 Waste Reduction & Energy Efficiency Conference, Livonia, MI (October 2004)
- R. Regan, "DTE Energy Hydrogen Technology Park," DOE Electrolysis-Utility Integration Workshop, Broomfield, CO (September 2004)

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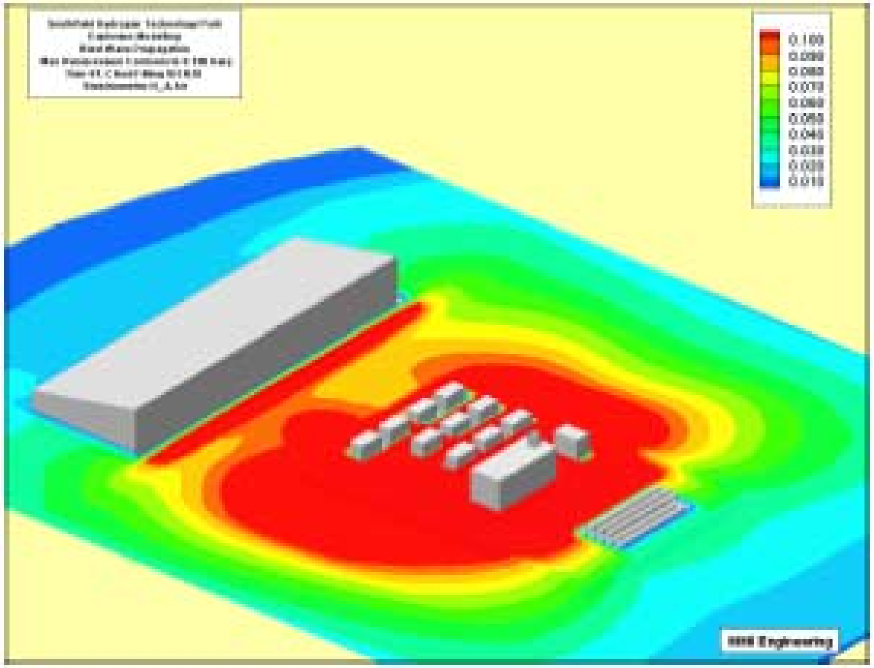
Hydrogen Safety

The most significant hydrogen hazard associated with this project is: Ignition in the IGEN electrolyzer compartment of a stream of released hydrogen under high pressure from storage. The expected overpressure and its effects on a future visitor center are shown below:



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Hydrogen Safety

Our approach to deal with this hazard is:

The hazard was further reviewed by explosion modeling as part of a Quantified Risk Analysis (QRA). The probability of having a large volume high pressure leak and then igniting it within the IGEN was calculated to be 9 x 10-7. This assumes the small bore tubing is unguarded and susceptible to damage and that the leak would be directed toward an ignition source. The QRA shows that even if ignition occurred that significant overpressure will be limited to the site property.

- We have protected all small bore tubing by installation below grade, guarding, or by location under substantial equipment.
- All electrical installations within 15 feet of storage and its associated tubing are rated for Class I, Division 2 locations.
- The IGEN is more than 15 feet away from storage and its associated tubing.
- The IGEN is continuously monitored for hydrogen, and the IGEN hydrogen detector will E-stop the entire site on detecting 40% LEL hydrogen or more.
- The IGEN programmable logic controller (PLC) is used to monitor storage pressure and will alarm on a loss of 50 psi over a ten-second period. This is significantly less pressure drop than the minimum expected pressure drop from a shear of the hydrogen tubing at the most remote location (i.e., the dispenser) when storage is at its lowest expected operating pressures (i.e., 110 psi in 10 seconds). After the system demonstrates operation without nuisance alarms, it will be connected to the hardwired safety system (HWSS) to provide an E-stop of the entire site upon detection of rapid mass loss.